Large scale urban traffic operations:

theory, empirics and control

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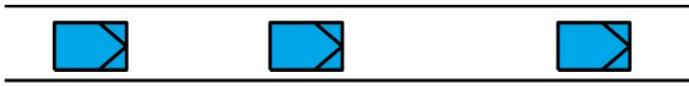
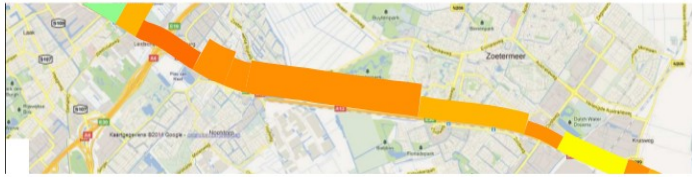
Scales of traffic desciption

- Microscopic: individual level

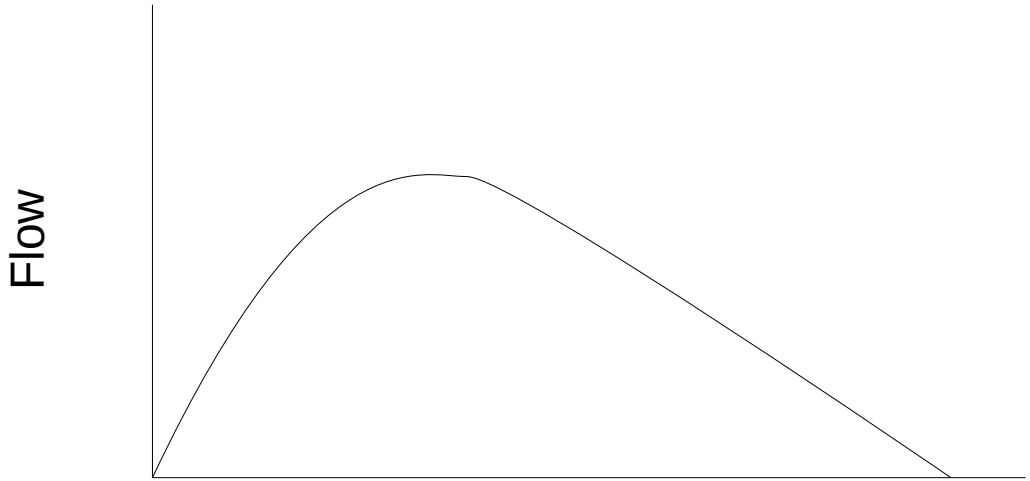


- Macroscopic: road level

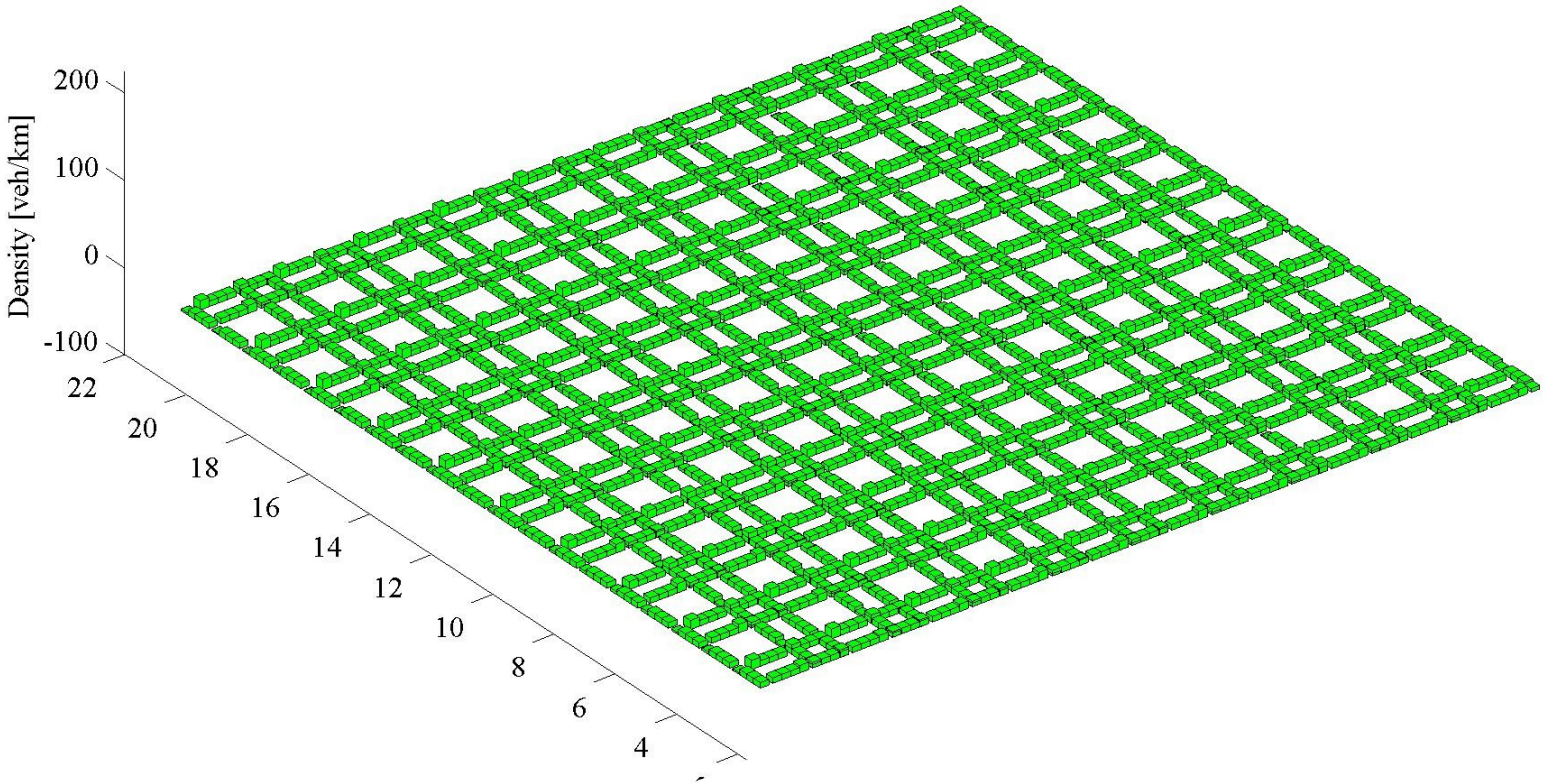


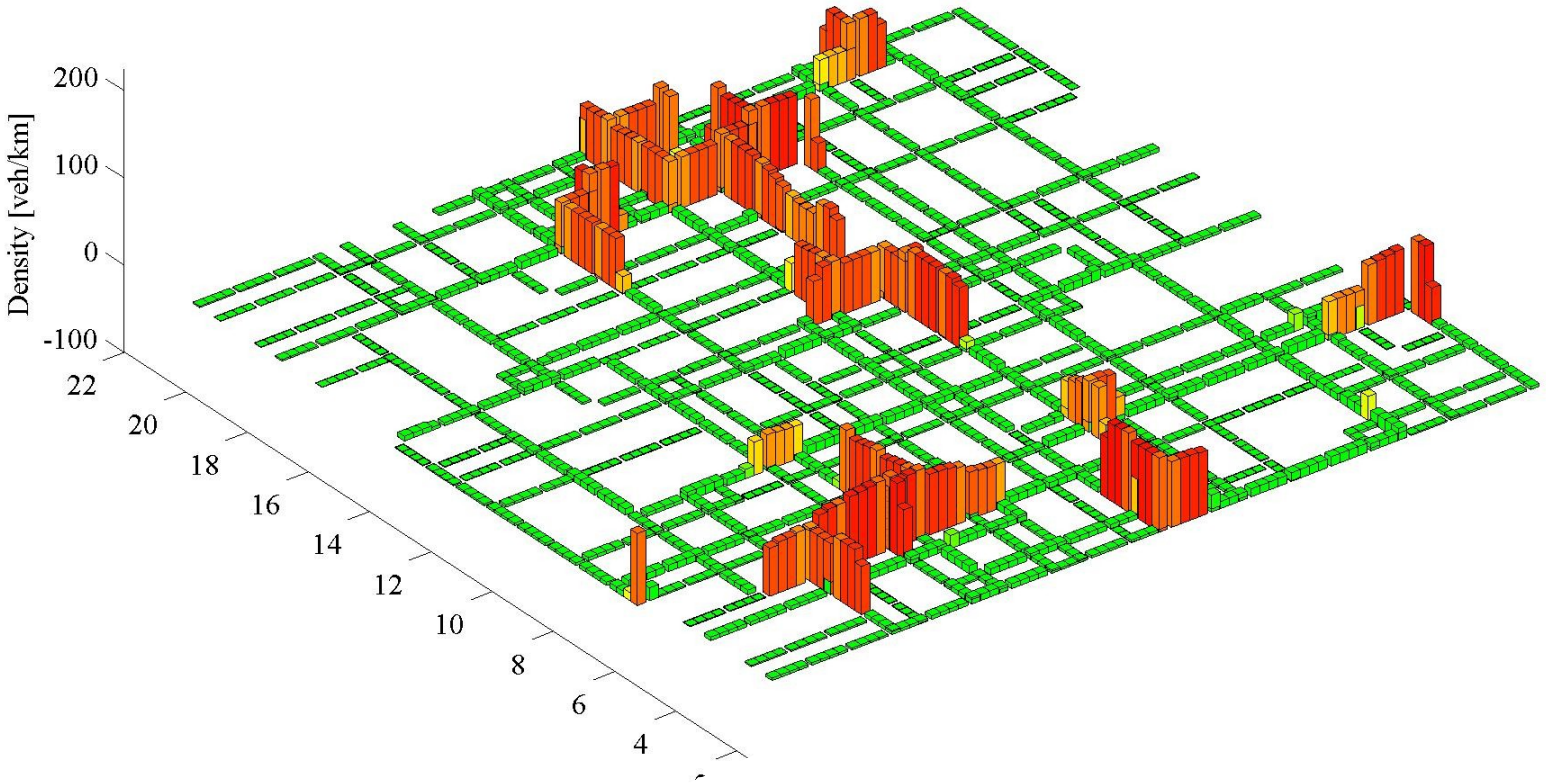
- Higher level: network level

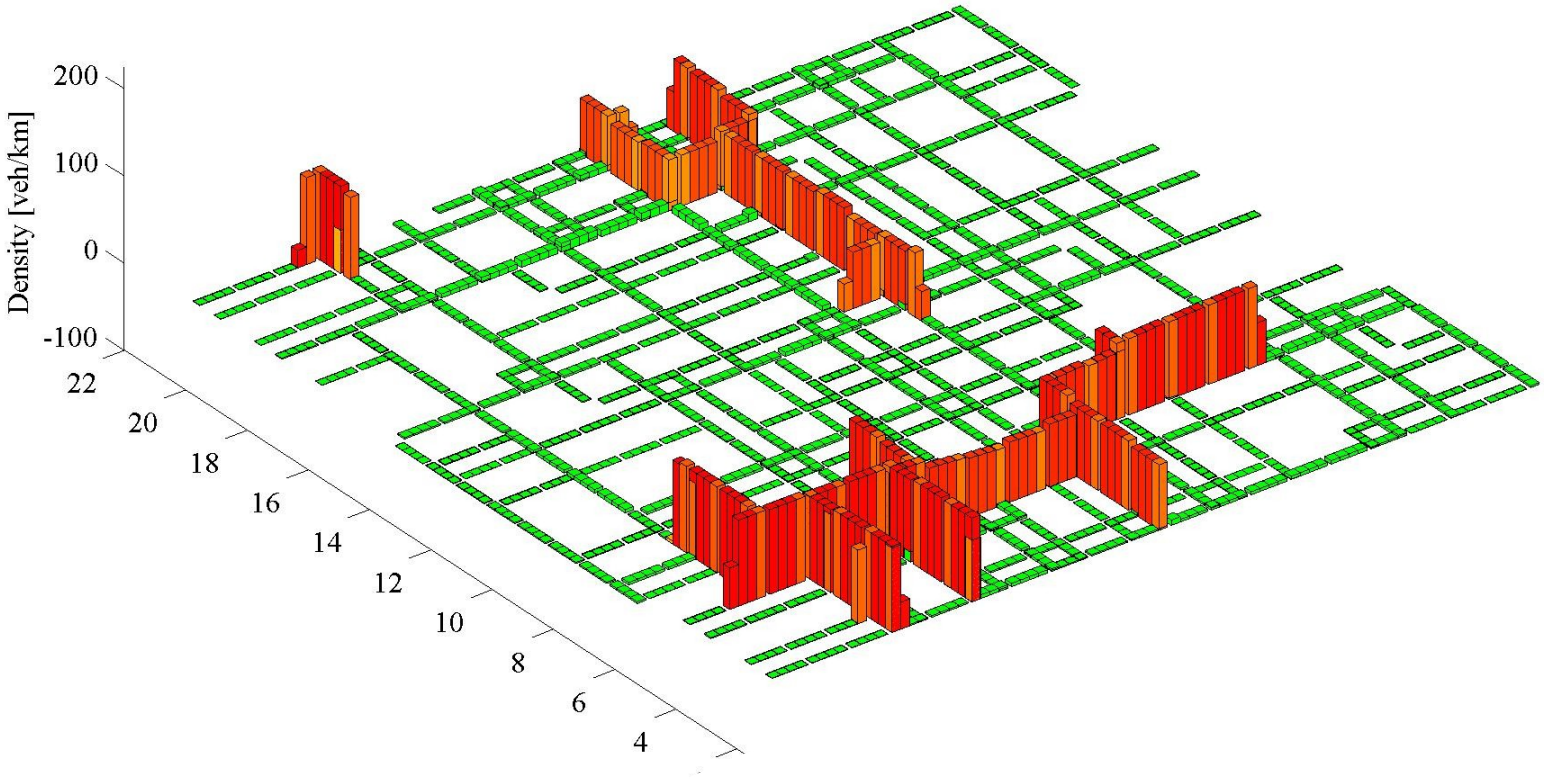
Relationships variables



Build up of congestion




Density [veh/km]
200
100
0
-100
22
20
18
16
14
12
10
8
6
4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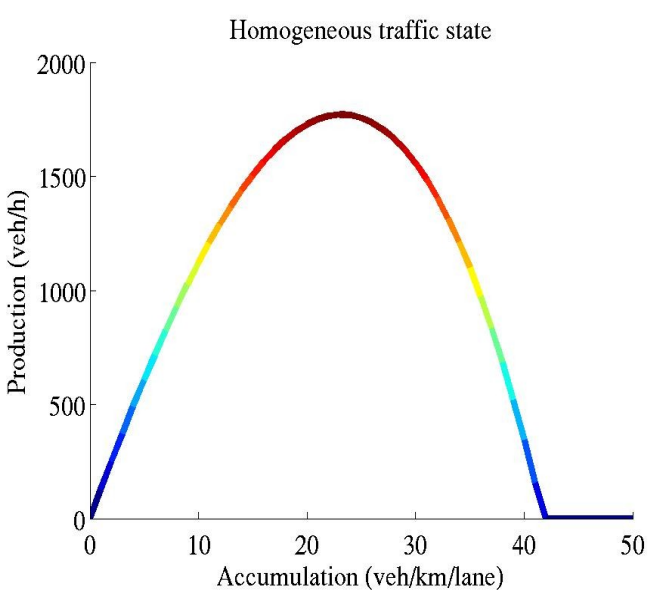
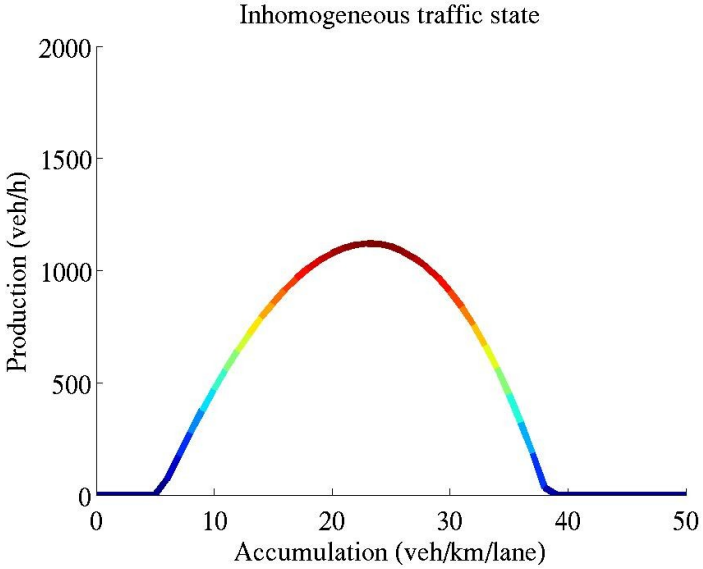
Fitting a functional form

P(A)=A*(c1+c2A+c3A2)-c4σ



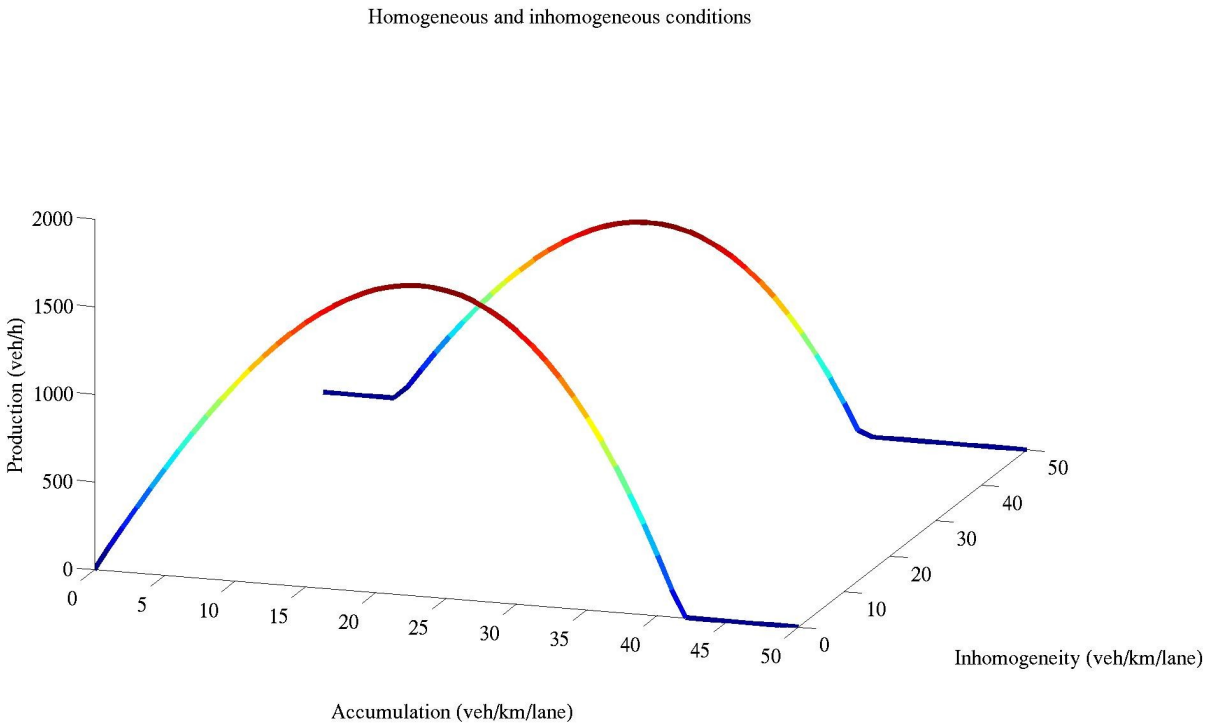
Homogeneous traffic situation



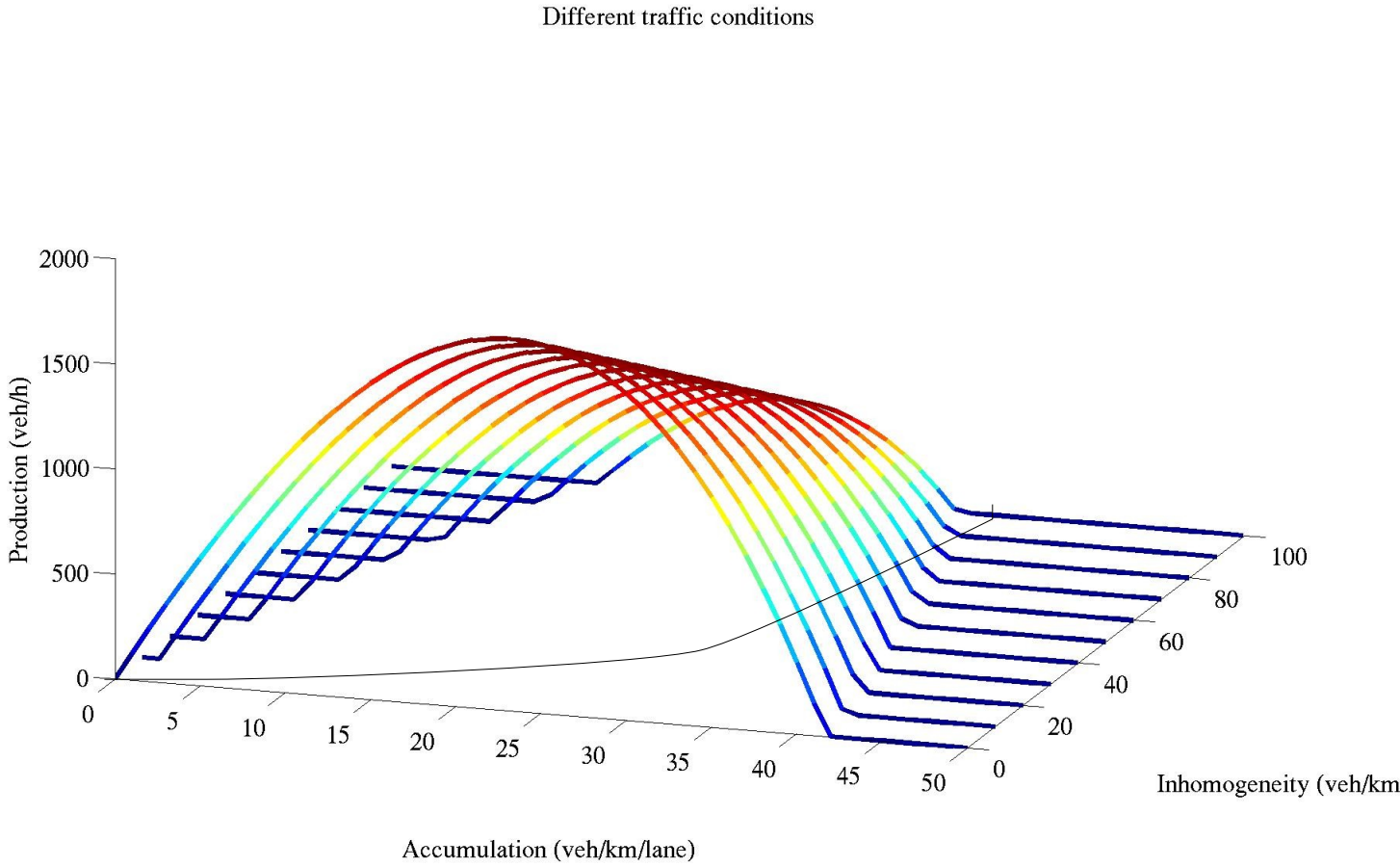
Inhomogeneous traffic situation

Fitting a functional form

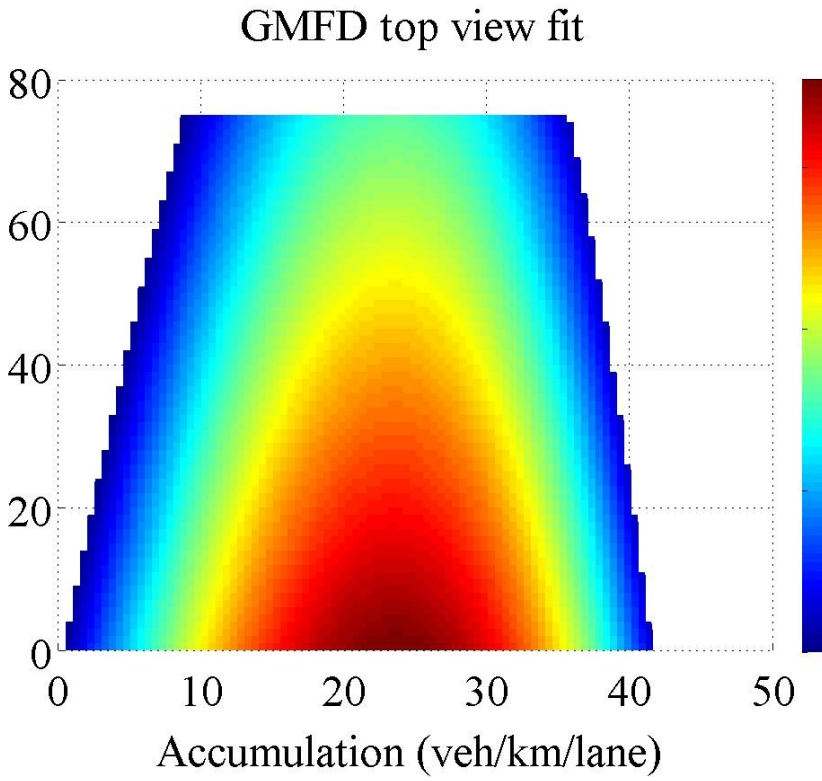
P(A)=A*(c1+c2A+c3A2)-c4σ



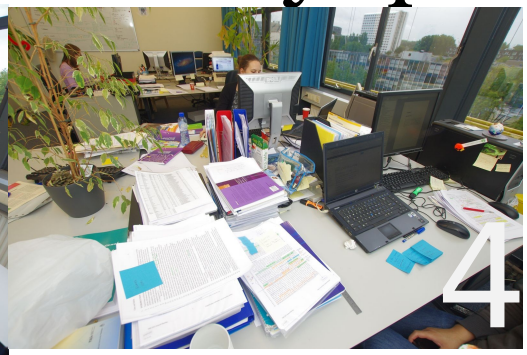
Fitting a functional form

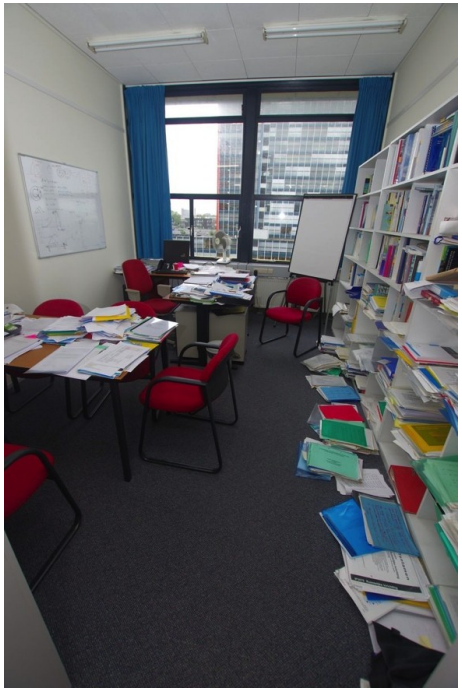


Empirical evidence



Suitable for any queuing application?





Further content

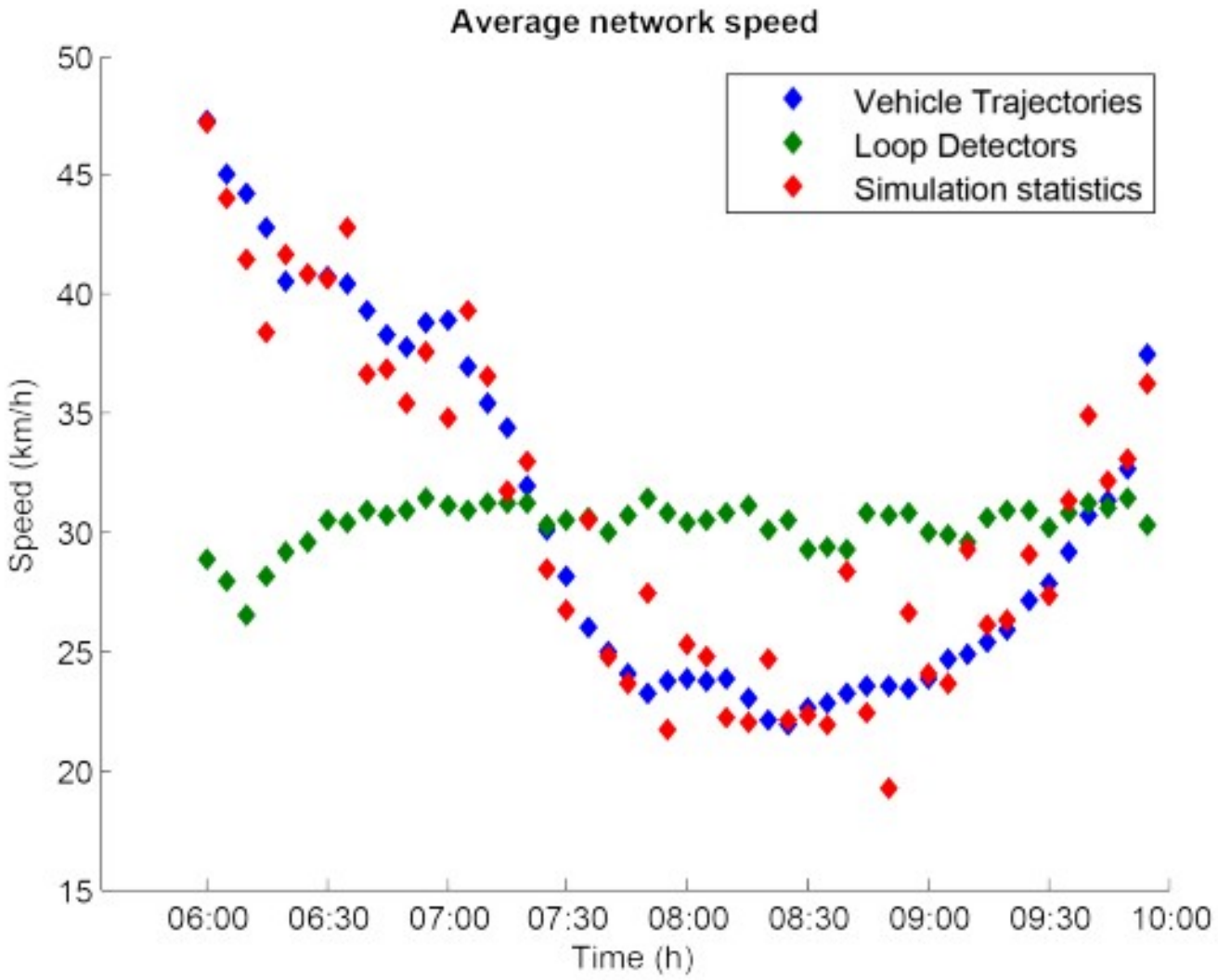
1) Empirics of MFD
2) Controlling: perimeter control and internal control

Floating car data

Estimation of MFDs

- Control based on MFD
- How does the MFD look like?
  - often found from (micro)simulation or taxi data
  - Loop detector data is unfeasible
- Cont(r)act with Google

Detector speeds not representative



Available data

- Speeds via all mobile devices
- (Scaled) flow on the roads
- Road segments length typically ~100 meters
- Aggregation time 5 min
- Total: billions (i.e., exp(9)) rows of data!
- Segment size lacks assumed equal

Results

- Not in sheets on the internet...

Perimeter control or internal control

Perimeter control?

Perimeter control?

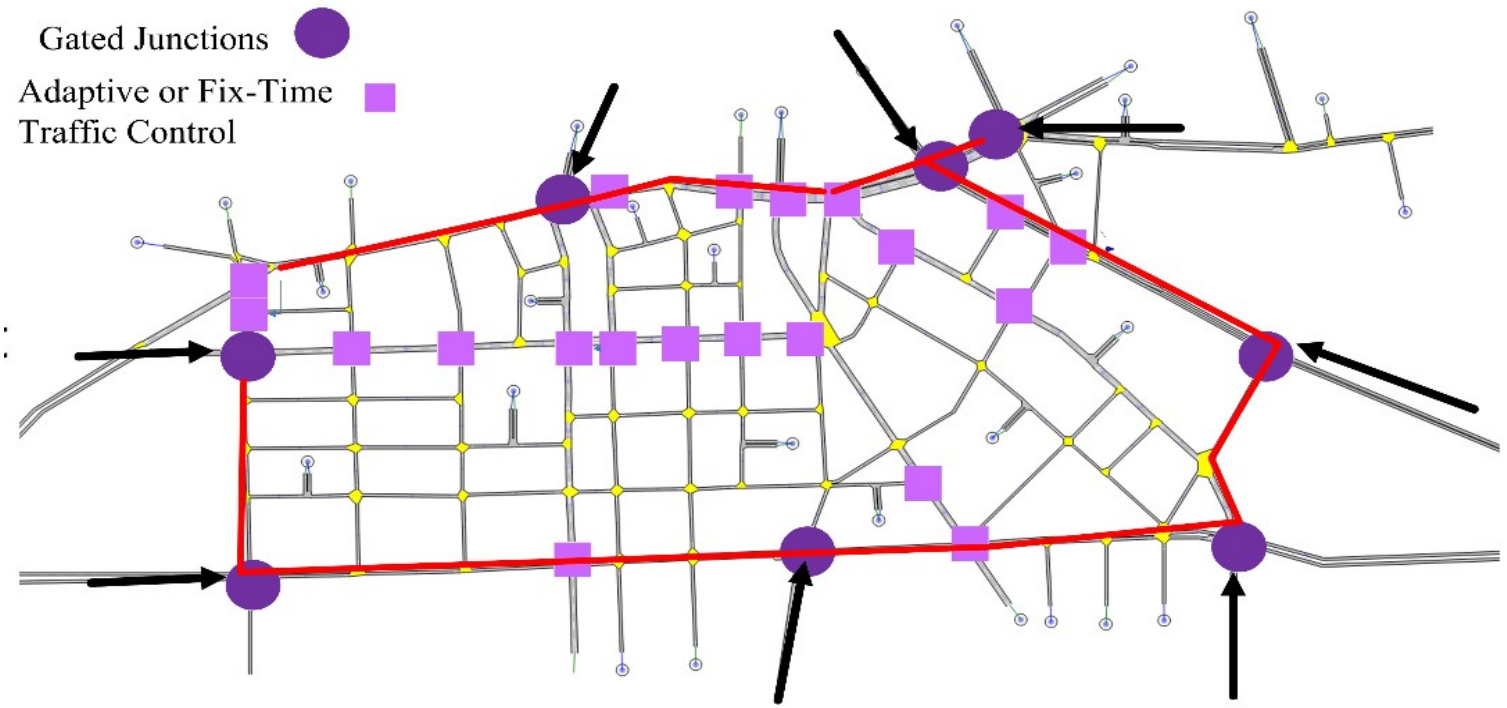
Aims for combinations

- Perimeter control: do not exceed the critical density
- Traffic lights: influence the internal flows (maximize)

- Combination:
  - Allow for inflow
  - Spread congestion evenly (i.e., reduce spread)

Control

- Lights for perimeter control
- Lights for internal control



Control schemes

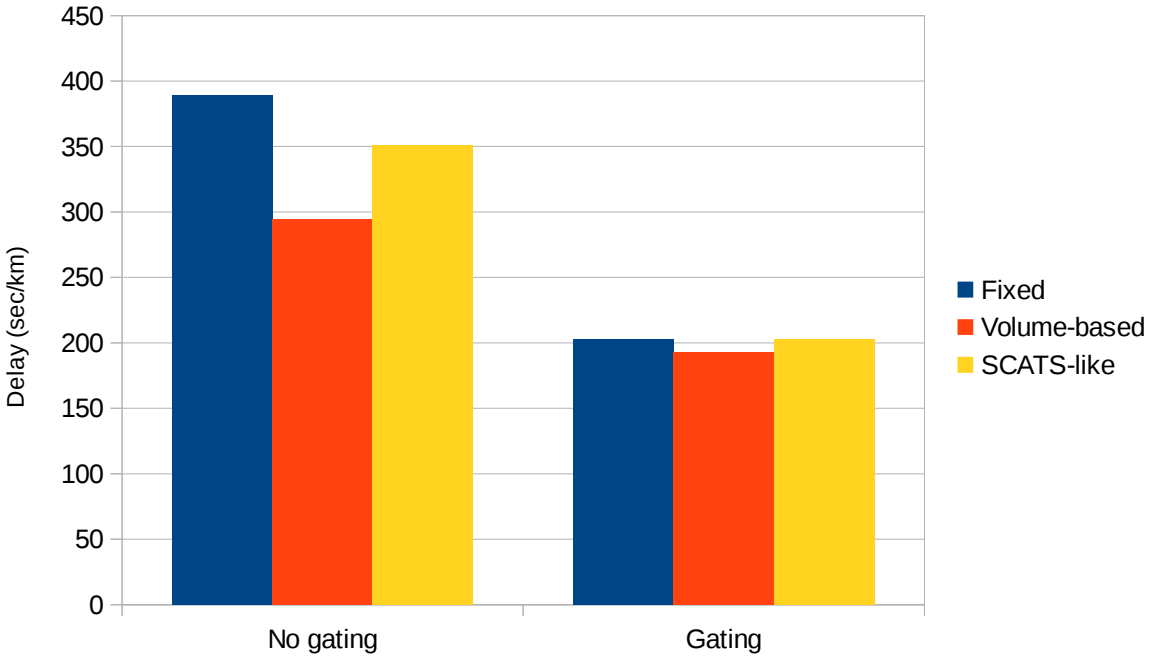
- Perimeter control: do not let too many vehicles in:

$$q_g(k) = q_g(k-1) - K_P\left[TTS(k) - TTS(k-1)\right] + K_I\left[T\hat{T}S - TTS(k)\right]$$

- Lights for internal control: three versions
  - Fixed time
  - Volume-based
  - SCATS-like (adaptive)

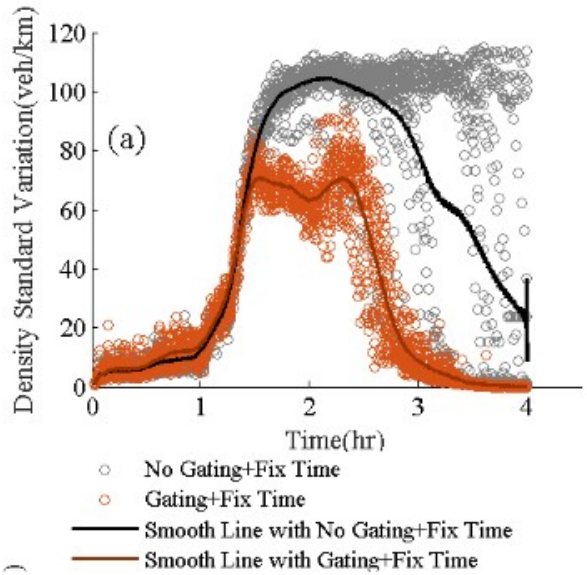
Results

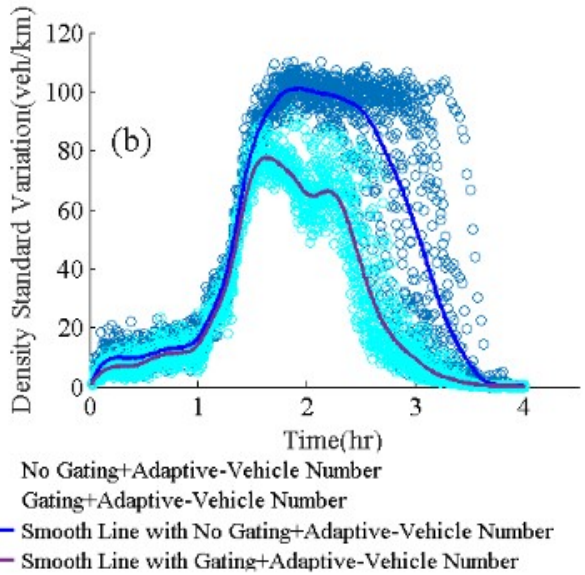
- Delays are lower for the gating situation
- Gating first, the rest comes later :-)

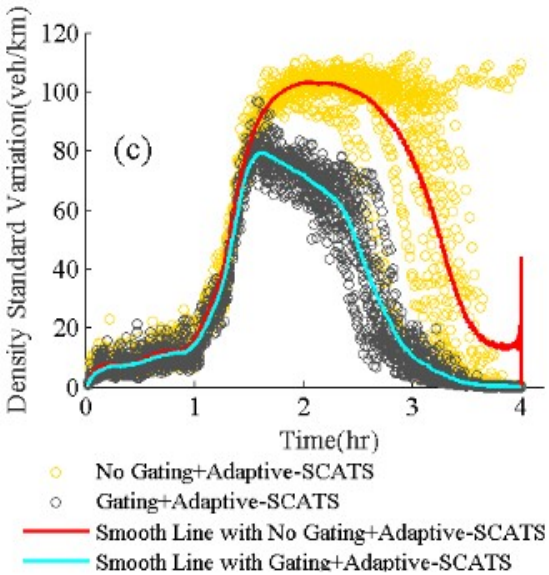


Traffic states

- Limiting the flow also helps having an equal spread







Concluding remarks

Conclusions

- MFD is a very rich and promising field of research and application
- Next steps:
  - Include more modalities (cyclists?)
  - Further work on dynamic modelling, and validate
  - Get it to work in practice!

Thanks to:

- Kay Axhausen
- Mehdi Keyvan-Ekbatani
- Vikash Gayah
- Serge Hoogendoorn
- Netherlands Organisation for Scientific Research (NWO)
- European Research Council (ERC)

Further reading:

- Knoop, V.L., Van Lint, J.W.C., and Hoogendoorn, S.P. (2015), Traffic Dynamics: its impact on the Macropscopic Fundamental Diagram, Physica A, Volume 438, November 2015, pp. 236-250
- Network-wide Traffic State Estimation using the Macroscopic Fundamental Diagram: A data fusion approach Marianthi Mermygka, TU Delft MSc thesis, 2016
- Keyvan-Ekbatani, M., Gao, X, Gayah, V. and Knoop, V.L. (2016), Combination of Traffic-Responsive and Gating Control in Urban Networks: Effective Interactions. Paper presented at the 95th Annual Meeting of the Transportation Reseach Board
- Daganzo, C.F. and Knoop, V.L. (2016) Traffic Flow at Pedestrianized Streets. Transportation Research part B, Volume 86, Pages 211-222
- Knoop, V.L. and Daganzo, C.F. (2017) The Effect of Pedestrian Crossings on Traffic Flow. In proceedings of the 96th Annual Meeting of the Transportation Research Board, 8-12 January 2017